TAB A

R & D CATALOG FORM

DATE: 23 June 1966

1. PROJECT TITLE/CODE NAME: Electrocolor Material Study

2. SHORT PROJECT DESCRIPTION: Evaluation and determination of potential improvements of present electrocolor systems. (A related project.)

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3. CONTRACTOR NAME:

4. LOCATION OF CONTRACTOR:

5. CLASS OF CONTRACTOR: Research & Investigation

6. TYPE OF CONTRACT: N/A

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7. FUNDS: FY 1966 / FY 1967 / FY 1968

8. REQUISITION NO.:

9. BUDGET PROJECT NO.: NP-R-5- 10057

10. EFFECTIVE CONTRACT DATE (*Begin - end*): 1 July 1966 - 30 June 1967

11. SECURITY CLASS.: A.A. - Confidential; T. - Unclassified; W. - Unclassified

12. RESPONSIBLE DIRECTORATE/OFFICE/PROJECT OFFICER TELEPHONE EXTENSION

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DDI/NPIC/P&DS

13. REQUIREMENT/AUTHORITY

The increasing use of color reconnaissance photography necessitates thorough investigation of all color reproduction systems to determine those advantages which can be applied to Center requirements.

14. TYPE OF WORK TO BE DONE

Applied Research

15. CATEGORIES OF EFFORT

MAJOR CATEGORY	SUB-CATEGORIES
Reproduction Techniques and Materials	Electrocolor Plating Materials Equipment

16. END ITEM OR SERVICES FROM THIS CONTRACT/IMPROVEMENT OVER CURRENT SYSTEM, EQUIPMENT, ETC.

This program is to evaluate and define the limits of the present electrocolor system. It is to be followed by development of improved electrocolor products and equipment for exploitation use.

17. SUPPORTING OR RELATED CONTRACTS (*Agency & Other*)/COORDINATION

Internal and external coordination is being maintained to insure that there is no duplication of effort within the community.

18. DESCRIPTION OF INTELLIGENCE REQUIREMENT AND DETAILED TECHNICAL DESCRIPTION OF PROJECT (*Continue on additional page if required*)

The electrocolor process shows potential for producing color reflection prints for exploitation use. Its unique characteristics of individual color contrast control of the three basic colors, red, green, and blue, indicates that this product would be extremely useful in exploitation use. There is also a potential for a color transparency material to be developed utilizing the electrocolor technique.

19. APPROVED BY AND DATE

OFFICE	DEPUTY DIRECTOR	DDCI

Declass Review by NIMA/DOD

TAB B

ELECTROCOLOR TECHNIQUE STUDY

TECHNICAL DISCUSSION

This study will determine the limitations and potential of the electrocolor processing system through the following 13 major areas of investigation.

A. Speed - The present low speed of the print material requires high illumination and/or long exposure times for large magnifications. Investigation of increasing the material speed by 5-10 times is included in the [redacted] subcontract effort. A decrease in processing time, as described elsewhere in this paper, is also to be investigated.

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B. Resolution - The true material resolution will be determined. Tests will be conducted to determine the resolution threshold of the material.

C. Latent Image Stability - The Electrocolor principle depends to a great degree on the ability to control the latent image in the zinc oxide layer. It is necessary to retain the latent image without degradation between exposure and plating; however, after plating any remaining latent image must be completely destroyed to prevent "image carry-over" and the sensitivity restored in preparation for the subsequent exposure. The purpose of this investigation is to determine the degeneration of the latent image after exposure as a function of time. In addition, tests will be performed to determine to what degree "image carry-over" exists between colors. This is a measure of the efficiency of the hot water wash to destroy the proceding latent image.

This aspect of the Electrocolor principle must be thoroughly investigated to provide a sound basis for any changes in design concepts.

D. Reciprocity Characteristics - This investigation will determine the limits under which variations of exposure time and intensity induce reciprocity failure. Reciprocal variations in exposure time and intensity result in a constant time/intensity product, but produce variations in print density. In the tri-color printing method used in the Electrocolor system, reciprocity failure in any of the three colors results in a color balance shift. If this condition exists, color analysis systems must be designed to compensate for this error. A test program will be conducted to determine the reciprocity characteristics of the present system in the normal range of machine operation.

E. Color & Contrast Control - The limits of color control are closely tied to the degree of reciprocity failure and the ability of the negative analyzer and control system to correct this error.

Testing will be conducted on the material, independent of the analyzer, to determine the color response to exposure variation. The results of the test will be presented on tri-linear graphs which will compare the actual to the optimum results.

One of the most striking advantages of the Electrocolor system is the ability to vary the gamma of the three colors independently or together to effect an overall contrast variation. Tests will be conducted to determine the sensitometric effects of variations in plating time and voltages. The results will be plotted as D Log E curves so that the limitations of the system can be determined.

F. Spectral Characteristics of the Print Material, Dyes, and Top Coating Materials - Non-conventional use of the Electrocolor system indicates high potential in false color and multispectral sensing. As a basis for future developments, a spectral analysis of the material, filters, and dyes will be performed. Some problems have been recognized in top coating techniques in which a degradation of the base white has become objectionable. A spectrophotometric comparison of the material before plating, after plating, and after top coating will show to what degree this condition exists. All specimens will be analyzed on a Beckman Spectrophotometer and the results presented as percent transmission or reflection versus wave length.

A portion of the spectral evaluation will include Kodak Ektacolor material for comparisons. This study will generate objective data regarding the color gamut of the Ektacolor material and the Electrocolor System with various top coating materials.

This color gamut will show the visual appearance of the various combinations of the image forming dyes. Further, it will furnish the range of colors it is possible to reproduce with a dye system. As would be imagined, this type of color map for a dye system is very sensitive to changes in the dyes, the sensitive material, the laminating or glossing process, and anything that alters the color tone reproduction and color fidelity of the system. Since it is sensitive in this manner, it becomes very useful in presenting a unified picture of how any changes made later in the color system affect the ability of the system to reproduce colors. Moreover, the results will be presented in terms of the human visual system.

G. Exposure and Development (Plating) Techniques - the present methods of exposure and plating have served adequately for the prototype equipment. These techniques, however, are limiting and a study will be conducted to determine the possibilities for the improvements in the exposing and plating operations.

H. Negative Analyzer and Control System - [redacted] color negative analyzer, built for [redacted] to use with the Electrocolor system, was designed for either spot or total integration analysis. 25X1 25X1

A series of tests will be made to determine the accuracy and the range over which this accuracy can be maintained in correcting off-color negatives. A series of control negatives will be prepared in which controlled errors are produced. The ability of the analyzer to correct these errors will give an indication of its capabilities.

I. Improvement of Access Time - The Electrocolor system provides a finished color print in much shorter time than conventional color processes. This gain, however, is confined to small quantity runs due to the sequential requirements of the processor. A full cycle must be completed for each print. Therefore, batch processing provides no advantage because additional time is consumed in dye bucket movement, wash and dry operations, and single sheet material handling.

This study will investigate these areas and determine if access time can be significantly reduced to make quantity production feasible.

The plan is to investigate at least four types of exposure/plating techniques which have potential access time reduction. The four that are now apparent are:

1. Sequential (mechanical modification of present system)
2. Concurrent Stage System
3. Traversing Mechanism
4. One-shot

(1) In the present machine, using the sequential exposure and plating technique, a print can be made in approximately 4 minutes. The actual time required to expose, plate, wash, and dry a print is approximately 60 seconds. An additional 3 minutes is consumed in non-productive mechanical operations. An investigation will be made to determine what mechanical modifications would reduce the access time.

(2) Concurrent Stage System - Although the problems appear to limit the potential of this system, it is felt that a study should be made of a design in which the print paper is moved from the exposing plane to the development stage. By the use of dichroic mirrors, the three spectrally separated images could be directed to three printing stages. The red, green, and blue exposures would be made simultaneously on three separate sheets of material. After plating, the three prints would be advanced and registered in the next stage. After the third advance, full color prints would be produced in approximately one-third the present time, or every 80 seconds. Problem areas are registration, complex mechanical movements, and elaborate electronic control requirements.

(3) Traversing Mechanism - Present indications are that a very rigid negative-print material relationship must be retained for precise registration. This requires that the dye application and plating operation be brought to the print material. If the exposures

were made by a moving slit, the plating anodes could then closely follow, utilizing a meniscus application of dye. A wash and dry module could be attached to the exposure slit/anode combination to complete a single color cycle. Like units could be attached for the other two colors and provide a finished print with a single traverse. Exposure variations could be controlled by light intensity, slit width, and traverse speed. Plating conditions could be controlled by anode width, traverse speed, and plating voltage. The advantages to be gained by this concept are:

a. Time consuming dye bucket, wash, and air knife movements can be eliminated.

b. During the traverse, exposure, plating, wash, and dry operations for all three colors can take place simultaneously at different points on the print.

c. Web material can be used.

d. Plating current requirements can be reduced due to anode area.

e. Machine size can be reduced.

f. Easel can be designed for horizontal operation.

g. Mechanical movements can be reduced.

(4) One Shot - This concept is probably the most sophisticated and the most difficult to accomplish. It is based on the use of an emulsion coating in which ZnO grains are spectrally selective. One-third of the grains are spectrally sensitized to red light, one-third to green light, and one-third to blue light. The dye bath is likewise composed of selective dye particles which, upon the application of the plating current, will be plated to the proper ZnO grain. The advantage of this system would be:

a. A single whitelight exposure (permits dodging and burning).

b. A single plating requirement.

c. Separate exposure and plating operations (exposure of next print can be simultaneous with the processing of succeeding print).

d. No registration problems.

e. No dark adaption (resensitization) problems.

f. Considerable reduction of access time.

g. Less elaborate printing and processing equipment.

J. Improvement of Information Content - The information content of a color photograph is to a great degree dependent upon: 1) the ability of the system to record shapes in fine detail, and 2) the ability of system to separate these areas by variation in hue, value, and chroma.

25X1 Representatives of the [redacted] have suggested that higher resolution material is possible with some loss in color fidelity. An investigation will be conducted to determine the limits and limiting factors for material resolution. Sample coatings designed for maximum resolution will be purchases and tested.

As a part of this study, a human factors investigation will be performed to give an indication of optimum dye combination to maximize visual acuity in false color detection. This human-oriented research will be designed to function in accordance with the color gamuts generated for the electrocolor dye system. It will involve the detection, by human observers, of specified targets of known size, hue, and purity against backgrounds of equal brightness but differing dye and/or purity.

This study, as presently envisaged, will not require a great deal of initial calibration to generate absolute visual data. The program does depend upon the generation of the color gamut for the Electrocolor system and its output should augment the color gamut program by stating, in terms of human factors, how the Electrocolor dye system may best be improved.

A study of various input materials, both color and black and white, is necessary to provide a basis for correlation of the information content of the negative materials and the ability of the printing system to reproduce. The value of information gain through the use of color material over black and white is rapidly becoming recognized. Further potential exists in the use of exaggerated and false color techniques. The Electrocolor systems has many advantages as a tool in investigating these areas. There are no inherent limitations, as in conventional multi-layer color materials, regarding a fixed spectral sensitivity/dye layer relationship. A red record black and white separation negative, for instance, can be projected with white light on the Electrocolor material and plated with any of the three dyes. With the variations possible in the choices of spectral band records and in the choice of contrast to which these black and white separations can be processed, coupled with the choice of dye combinations available, a tremendous variation of information output is possible. It is even conceivable that spectral bands outside the visible spectrum (IR near red) can be translated into the visible spectrum and provide a color display of variations in energy at specific wavelengths. The potentials in this area are not fully know, and the degree to which this information is usable is yet to be determined. An investigation into the potentials of the electrophotographic system to extend the information content coupled with a human factors analysis of the usability of the information will be undertaken.

K. Larger Format - The present print material is limited to an $8\frac{1}{2}$" X 11" format. Increased format sizes up to 16" X 20" will be investigated. This study will closely coincide with the study and tests for improving plating-current techniques. (Item G)

L. Development of Reversal and Transparency Printing Potential - The ultimate color photographic reproduction system would include the capability to produce color prints or transparencies from color negatives or positives. This study will investigate the use of electroplating techniques, in reversal printing, to produce transparent print material.

M. Results of Study - The final report for this program will include all possible improvements on the Electrocolor system supported by laboratory models to validate the finds of the program. The report will also include a detailed outline for construction of a breadboard model of optomized electrophotographic equipment.

The fabrication of a breadboard model and then of a prototype machine with improved speed, resolution, production rate, print size, and product flexibility is considered future work and is not included in this program.